

QUT Digital Repository:
<http://eprints.qut.edu.au/>



Hughes, Stephen W. (2008) Stellarium – a valuable resource for teaching astronomy in the classroom and beyond. *Science Education News (SEN)* 57(2):pp. 83-86.

© Copyright 2008 The Astronomical Society of Australia Inc.
Reproduced with permission of the copyright owner.

Ideas for the Classroom

Stellarium – a valuable resource for teaching astronomy in the classroom and beyond

By Stephen Hughes – Chair of the Education and Public Outreach Committee (EPOC) of the Astronomical Society of Australia (ASA) and member of the International Astronomical Union (IAU)

Department of Physical and Chemical Sciences, Queensland University of Technology, Gardens Point Campus, Brisbane, Queensland 4001 sw.hughes@qut.edu.au

A crisis in science education in Australia

In Australia, there is concern about decreasing numbers of high school students electing to study the enabling sciences in years 11 and 12. A report issued by the Australian Council for Educational Research (ACER)¹ makes it very clear there is a crisis in Australian science education and elsewhere in the developed world. The ACER report presents data from various sources that demonstrate a decline in the fraction of high school students electing to study science. For example, in Australia, between 1978 and 2002, the percentage of year 12 students studying physics fell from 27% to 12%, those studying chemistry reduced from 30% to 15% and those studying biology declined from 55% to 20%. As might be expected, the decline in the number of high school students studying science has led to a reduction in the number of students studying science at university and a consequent reduction in the number of science teachers.

What can be done?

A range of strategies have been suggested to try and improve the situation, some of which are described by Tytler (2007) and references therein. One obvious solution is to make the teaching of science more interesting rather than a litany of facts. There is evidence to suggest that school students, as well as the general population, are excited by astronomy – hence the relatively large amount of media coverage of astronomy compared to the other sciences. The International Astronomical Union (IAU) put forward a resolution in 2003 that asserts: “...astronomy has a proven record of attracting young people to an education in science and technology and, on that basis, to careers in space-related and other sciences as well as industry”².

A potential hurdle in the application of this resolution is the availability of ready-to-go teaching materials.

In this article I will briefly discuss a computer program, *Stellarium*, which is a teaching resource that can be used to teach the basics of astronomy. A major advantage of the program is that it is free and can be downloaded from the internet for Mac, PC and Linux computers³. A manual and a large amount of educational material for all school grades is available from the website.

Using Stellarium

Stellarium is very easy to use. An example option display window is shown in figure 1. When Stellarium is run it displays the sky as seen from a particular location, date and time as set on the computer. Once the location has been set every time the program is run the sky is displayed for the current time. I experienced an example of the link between screen and sky on the evening of the 28th Aug 2007 while watching a total eclipse of the moon. As I looked through the window at the computer screen I could see the ‘virtual’ eclipse looking exactly the same as the real eclipse in the sky! The program is literally like having your own personal planetarium.

The display is very realistic – when demonstrating the program, I often find that people assume that the program is linked to some kind of webcam showing the sky in real time! The initial view of the night sky is similar to what is actually seen outside. However, there are a number of useful additions to the basic view of the starry night. For example, the constellations can be drawn in as lines joining stars along with the name. There is also an option to draw artwork over the lines to aid the imagination and different landscapes (e.g. paddock, ocean etc) can be selected to increase realism.

Another useful feature is the ability to draw lines of ‘latitude’ and ‘longitude’ on the celestial sphere. This is effectively projecting lines of latitude and longitude on the earth out into space. There is also an option to display azimuthal lines, which are similar

Stellarium (continued)

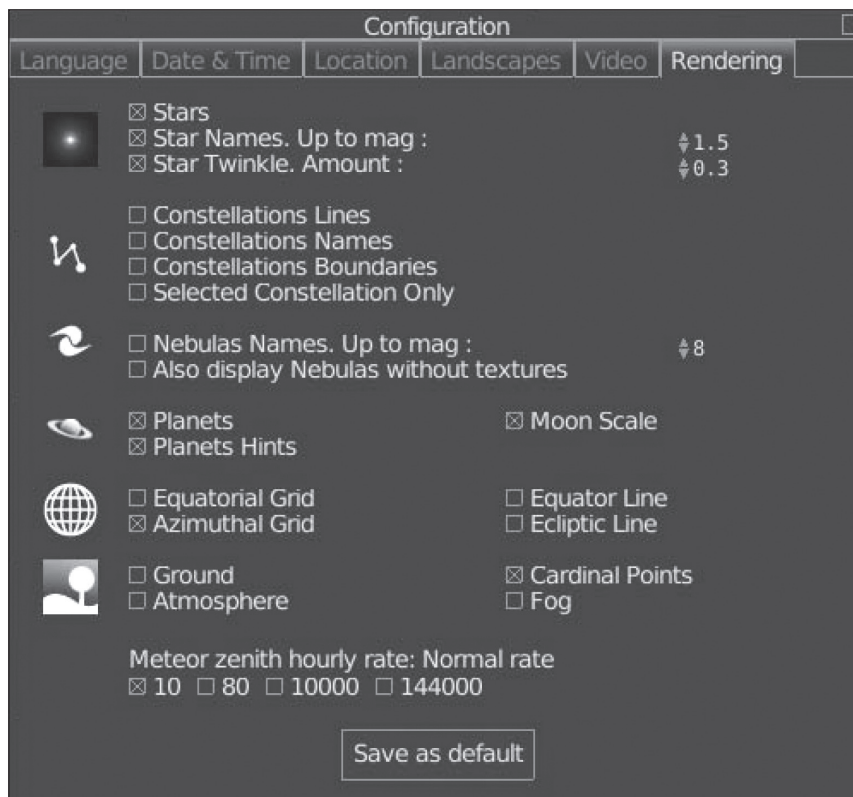


Figure 1. The configuration screen showing the display options that can be set in Stellarium. These options can be changed while the program is running – for example the atmosphere and ground can be switched on and off as required. Most of the options in the configuration window are accessible from an icon bar at the bottom left of the display. Other option windows appear when the tabs at the top of the window are clicked. For example, the “Date and Time” tab enables the current date and time to be set.

to the latitude and longitude lines except the ‘pole’ is directly overhead at the zenith and the equator is at the horizon. When Stellarium is run, the sky moves in real time, however the speed can be increased so that it is easy to see how the stars move. For example, when the celestial sphere grid lines are switched on the stars are seen to rotate around the South Celestial Pole south of the equator.

Stellarium is also a good tool for learning the constellations – I personally find the program easier to use in this respect than a static star chart. Stellarium has a night mode that displays text in red so that dark adaptation of the eyes is maintained when viewing the screen. This option enables the program to be used on a laptop under dark skies.

The location view can be opened and the cursor moved across a map of the world. As the cursor moves, the view of the sky from that point on the earth’s surface is displayed. If the cursor is moved horizontally a point is reached where the sun sets and it becomes dark – this is the terminator – the dividing line between day and night. If the date is set to the *vernal equinox*, i.e. 21st March, the sun will rise exactly in the east and set in the west. If the date is advanced one month at a time it will be seen that the sun rises either south or north of east depending on the time of year. The path of the sun in the sky, called the *ecliptic*, can also be switched on^α. (The planets also travel close to the ecliptic).

^α This is the passage of the sun against the fixed stars and not the path of the sun in the sky during the day.

Stellarium (continued)

Navigating amongst the stars

Stellarium is a powerful tool for teaching students the basics of celestial coordinates. As knowledge of the terrestrial coordinate system (i.e. latitude and longitude) is required to successfully navigate on the earth^β, so knowledge of celestial coordinates is required to navigate across the celestial sphere. In astronomy, the coordinates of a celestial object with respect to the lines of longitude and latitude are known as *right ascension* (RA) and *declination* (DEC).

The position of a celestial object above or below the celestial equator is known as the *declination* of the object, or DEC for short. The DEC varies between 0 and +90° for stars north of the celestial equator and 0 and -90° for stars south of the celestial equator. The DEC coordinate of a star is equivalent to latitude. The RA is a measure of angular distance of a celestial object from a fixed point on the celestial equator. This is equivalent to longitude in terrestrial coordinates where the longitude of a location is the angle between the *Greenwich meridian* (the 0° longitude that passes through London, UK) and the meridian passing through that point on the earth's surface.

The question is, in astronomy which longitude line is equivalent to the Greenwich meridian on the earth? This line is the celestial meridian that passes through one of the two intercepts of the ecliptic and the celestial equator. These intercepts are known as the *equinoxes* and are the points where the sun crosses the celestial equator, i.e. the point in time when the centre of the sun is directly overhead at the equator. These dates are around 20th March (*vernal equinox*) when the sun crosses from south to north and about 23rd September (*autumnal equinox*) when the sun travel from north to south. The vernal equinox is the point that has been chosen as the RA origin.

This intersection point is known as the *First Point of Aries*, given the symbol Υ . (However, due to something known as the precession of the equinoxes, Υ is now in the constellation Pisces on its way to Aquarius). Υ is sort of equivalent to the intersection, known as the *Greenwich meridian*, with the terrestrial equator. You can see this point

in Stellarium by switching on the Equator Line and the Ecliptic Line (figure 1). You will see the two equinoxes – the vernal equinox is the point with RA and DEC coordinates close to zero.

In 2008 the sun crossed the celestial equator at 5:48 GMT. You can experience this event in Stellarium by setting the date to 19th March 2008 and advancing through the 20th March to the 21st – you will see the sun cross the celestial equator. If you zoom into the sun you can find the time the exact time the sun crosses the celestial equator. If you go to around 23rd September you can see the sun go the other way.

The location of a star on the celestial sphere is specified in term of the angle between the meridian of the object and the meridian of Υ . This is effectively the celestial longitude of the object, however, the angle is specified in terms of time rather than degrees. The earth takes 24 hours to rotate on its axis so 24 hours is equivalent of 360° of RA and therefore 1 hour of RA is equal to 15°. Since the sun, moon and planets move against the face of the celestial sphere they do not have fixed celestial coordinates but have coordinates specified for a particular moment in time. If an object cannot be seen with the naked eye it would be almost impossible to point a telescope in the right direction without knowing the celestial coordinates. The earthly and heavenly coordinate systems are brought together in *celestial navigation* – the technique used by the ancient mariners to sail across the oceans.

In Stellarium, whenever a point on the sky is clicked, the celestial coordinates appear in the top left hand corner. To explore this feature it is best to switch on the celestial coordinate system. It is easy to see that all points above the celestial equator have a positive DEC and all those below a negative DEC.

The movement of the planets (their name in Greek means *wanderers*) against the backdrop of the celestial sphere can easily be seen by using the magnifying glass symbol to locate the planet (e.g. Jupiter) and advancing the date a month at a time. The planet will move relative to the constellations. (The movement can be seen more clearly if the constellation drawings are switched on).

^β GPS navigation units use latitude and longitude to calculate routes.

Stellarium (continued)

As the earth goes on its way around the sun the rotation axis of the earth points in more or less the same direction⁸. This means that as the year progresses the view of the night sky changes. Each night the stars in the east rise four minutes earlier than the previous night. This can be demonstrated on Stellarium by setting up a view facing the eastern horizon and advancing time one day at a time so that the same time is displayed for each night. Each night, the stars will appear higher and higher above the eastern horizon. After 365 days, i.e. one year, the stars arrive back at the same position relative to the horizon.

Another useful feature in the latest version of Stellarium is the display of star colour. Stars are effectively classified according to their colour. For example, red stars, e.g. Betelgeuse in the constellation Orion and Antares in Scorpio are M type stars. Yellow stars like our sun are G type stars. Stellarium also gives the brightness and colour ratio of selected stars, for example the star Betelgeuse in Orion has a magnitude of 0.45 and a colour ratio B-V = 1.52. A positive colour ratio indicates that a star is red in colour. A useful feature of Stellarium, is that information about a star is displayed in text of similar colour to the star.

How can Stellarium be used in the classroom?

A burning question is how would Stellarium be best used in the classroom? A teacher could introduce Stellarium to students in the classroom and encourage them to explore the program at home. Maybe an assignment could be based around Stellarium. As an example, Stellarium could be used to get students to explore the reason why it gets darker quicker at lower latitudes (i.e. closer to the equator). Students who live in northern Australia – say north of Brisbane, who have visited southern states may have noticed that the twilight period last longer in the south compared to home.

Students could be set the task of ‘visiting’ various places between the equator and either the south or north pole and use Stellarium to measure how long it

takes the sun to set. This can be done by measuring the interval of time between first and last contact of the sun with the horizon⁹. For example, I used Stellarium to measure the time for the disc of the sun to cross the horizon when viewed from Brisbane and Adelaide on the 21st June 2008 – in Brisbane it took 2 minutes and 20 seconds and in Adelaide 2 minutes and 50 seconds – 30 seconds longer in Adelaide. This means that it will take longer for the sun to drop to the point below the horizon where the sky becomes dark, hence the period of twilight is longer in Adelaide than Brisbane.

Students will be able to discover that the angle of the path of the setting sun with respect to the horizon varies with latitude. At the *solstices* (effectively the dates in the calendar exactly half way between the equinoxes) the sun sets at right angles to the horizon at the equator and so sets in the shortest possible time. At either pole, at the solstices, the sun travels through the sky at a constant height above the horizon. Stellarium can be used to demonstrate that above the Arctic and Antarctic circles the sun stays either above or below the horizon for six months at a time.

Stellarium is an excellent teaching resource for teaching astronomy at all levels. In this article I have only touched on a few of the features, there are a whole host more. The current government in Australia is committed to increasing the number of computers in school classrooms and improving the broadband internet access throughout the country. Over time, this will make it easier for teaching resources, such as Stellarium, to be used in the teaching of science.

References

1. International Astronomical Union (IAU) Commission 46 (Astronomy Education and Development), IAU Resolution on the Value of Astronomy Education passed by the IAU General Assembly, 2003, <http://physics.open.ac.uk/IAU46/resolution.html>.
2. Tytler, R. 2007, *Re-imagining science education – engaging students in science for Australia's future*, Camberwell, Victoria: The Australian Council for Educational Research Ltd. (http://www.acer.edu.au/research_reports/AER.html)
3. The Stellarium program, and educational materials can be downloaded from www.stellarium.org

⁸ Over the course of a year there is a change in the direction that the rotation axis points due to precession of the equinoxes – but it is extremely small – only about 0.014°. Precession of the equinoxes can be demonstrated using a spinning top – when the top is spun the end of the spindle goes round in circles or *precesses*.

⁹ I switched off the atmosphere and ground to be able to accurately measure how long it took the disc of the sun (which appears in actual size) to cross the zero degree azimuthal line.